Research on acoustic wave manipulation by acoustic metamaterial design

基于声学超材料的近场点声源亚波长分辨率显微成像模拟

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COMSOL CONFERENCE 2015北京

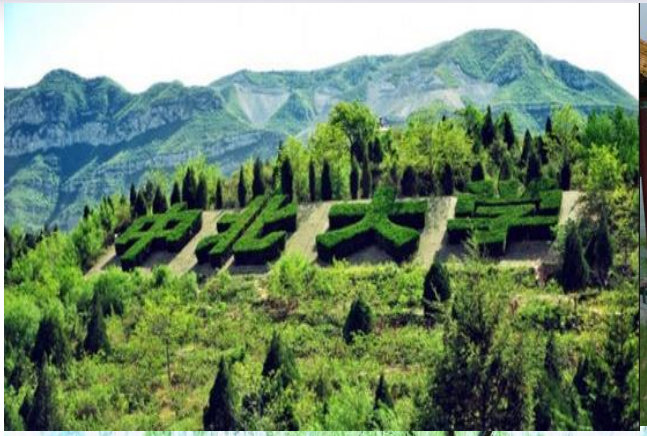
Excerpt from the Proceedings of the 2015 COMSOL Conference in Beijing

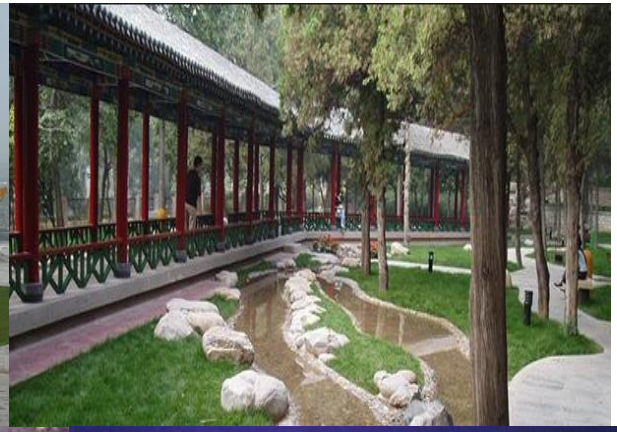
North University of China

1941年建校，誉为中国的“军工泰斗”和“人民兵工第一校”

The largest amount of scientific research funds in Shanxi Province

Welcome everyone to our university





Beautiful scenery love at first sigh friendly and hospitable

Special lecture outline

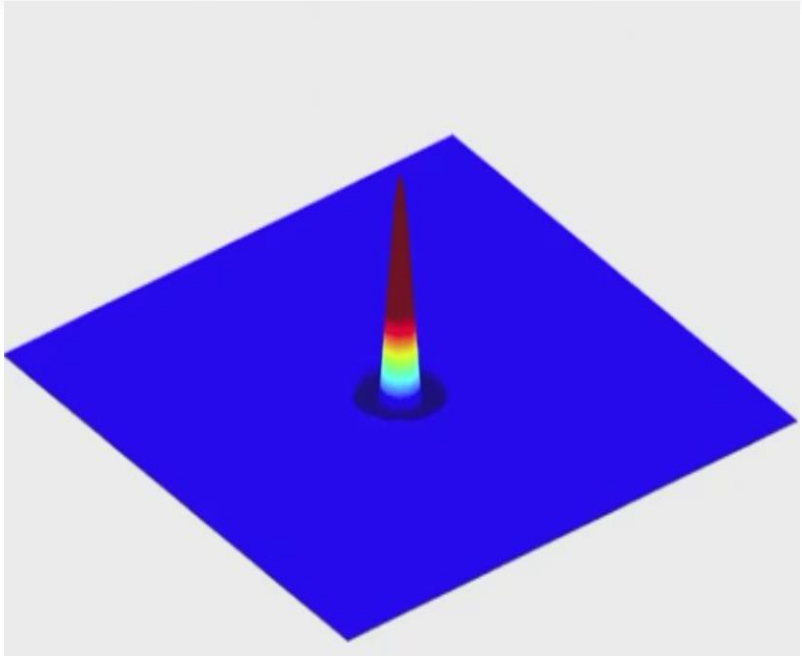
1. Research Background

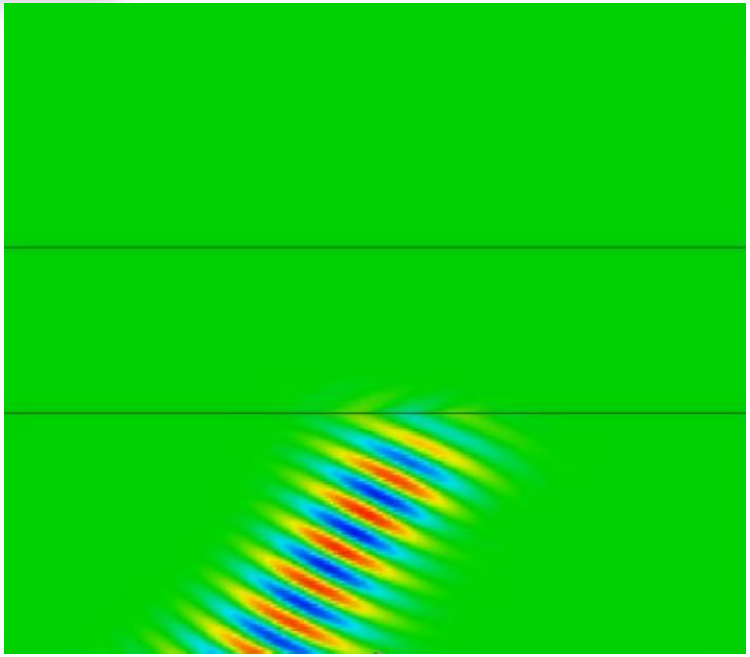
2. Research Foundation

3. Current Research

4. Research Prospects

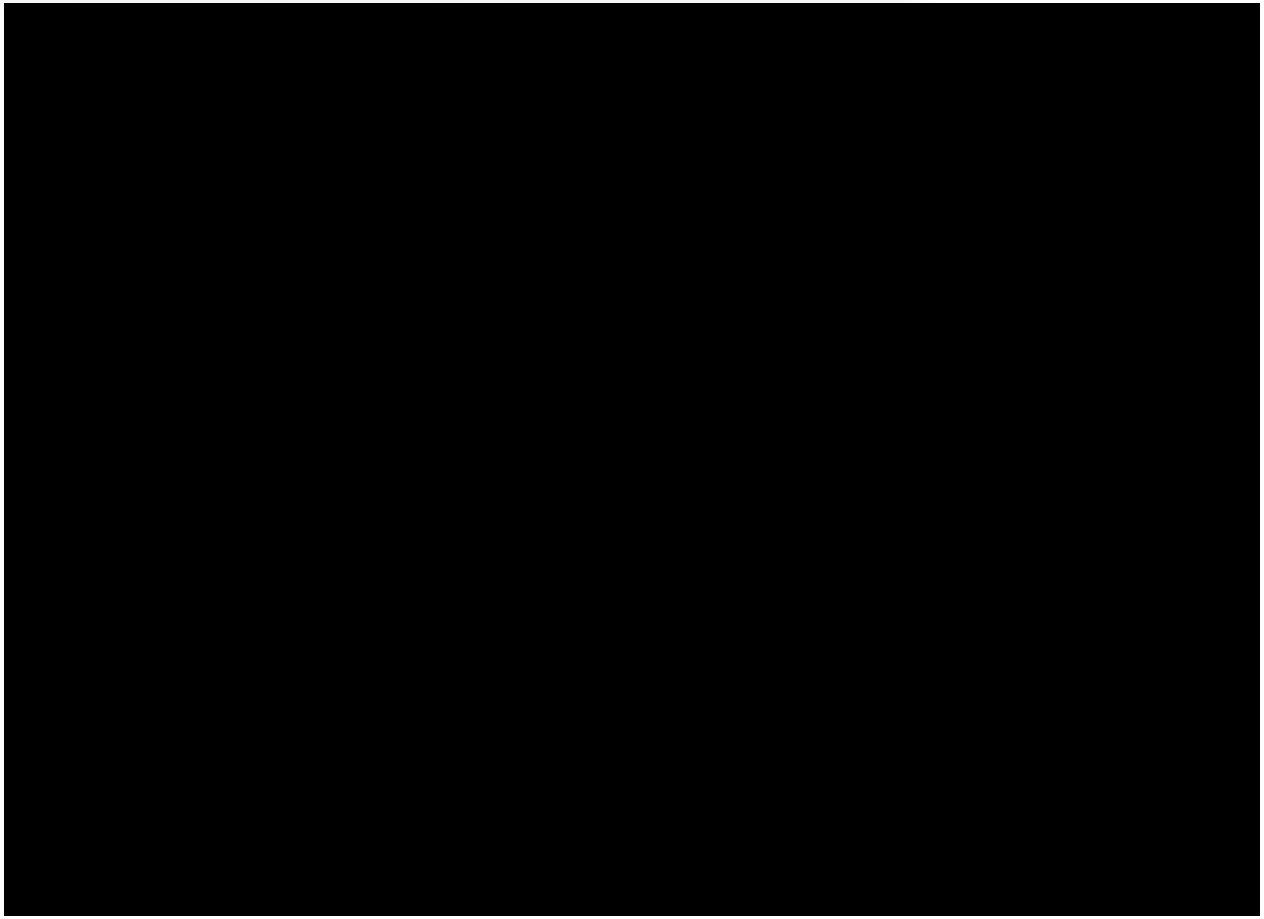
Conventional analysis of physical phenomena





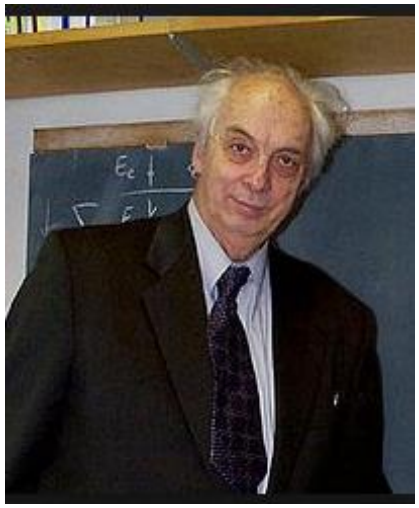
Point source radiation field

Refraction phenomenon



Negative refractive index

Victor Georgievich Veselago
(born 1929 in Ukrainian USSR)
a Russian physicist
In 1967 the first publish

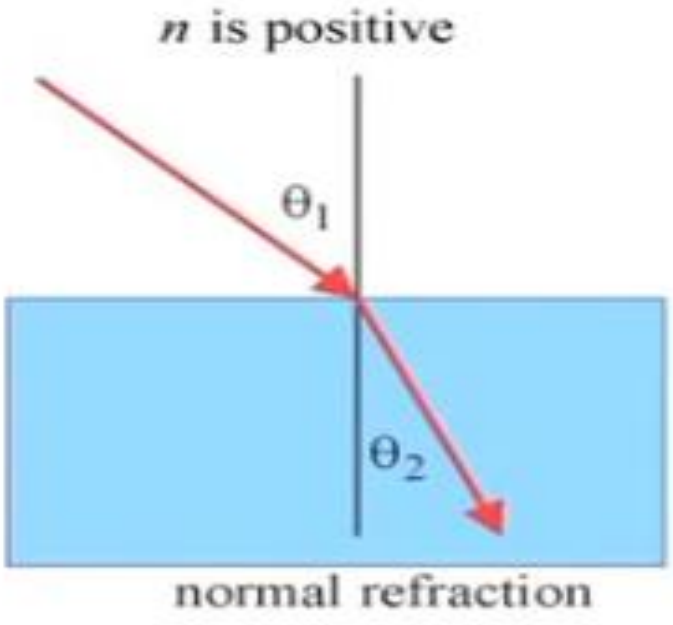


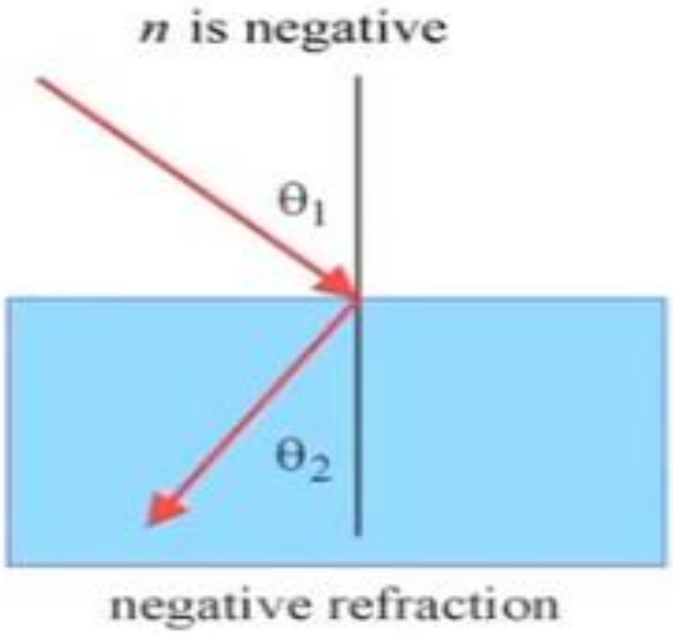
John Pendry
(born 1943 in Manchester)
an English physicist
the first practical
Negative refraction in 2000

The basic scientific principles

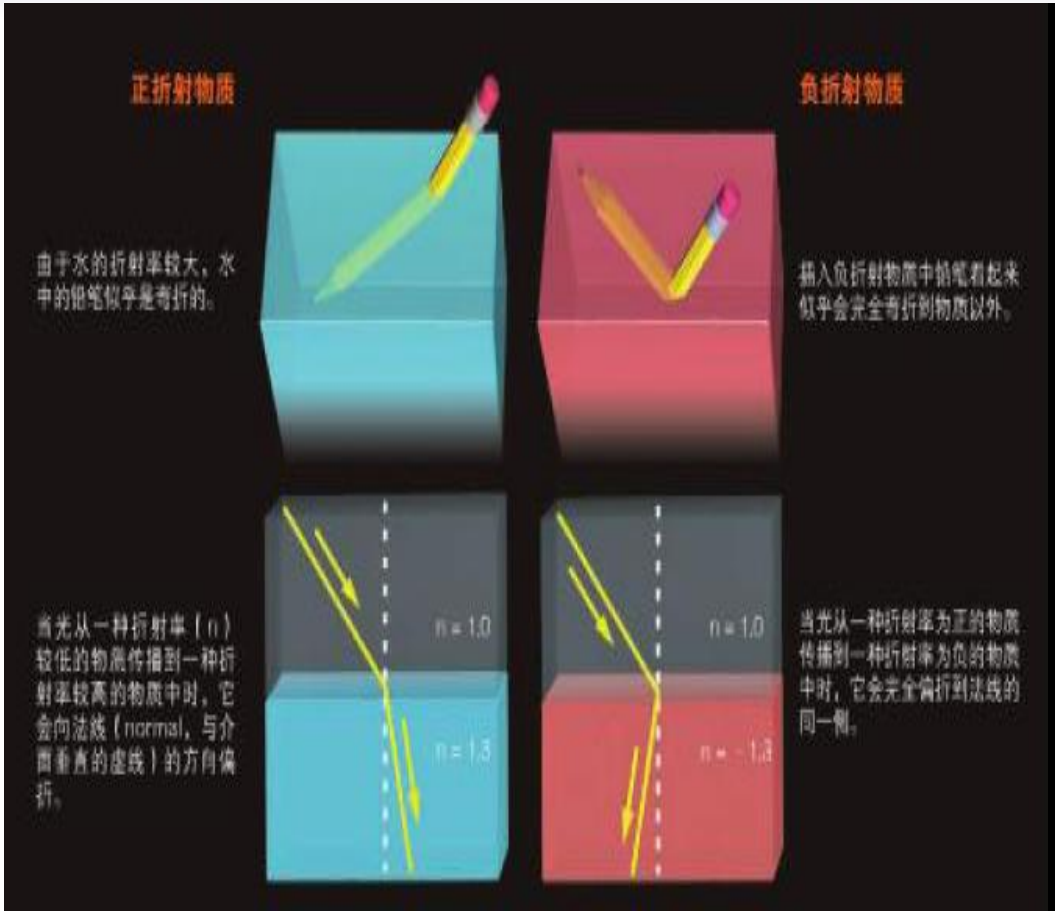
Negative refraction – Veselago

refractive index $n = \frac{\sin\theta_1}{\sin\theta_2}$

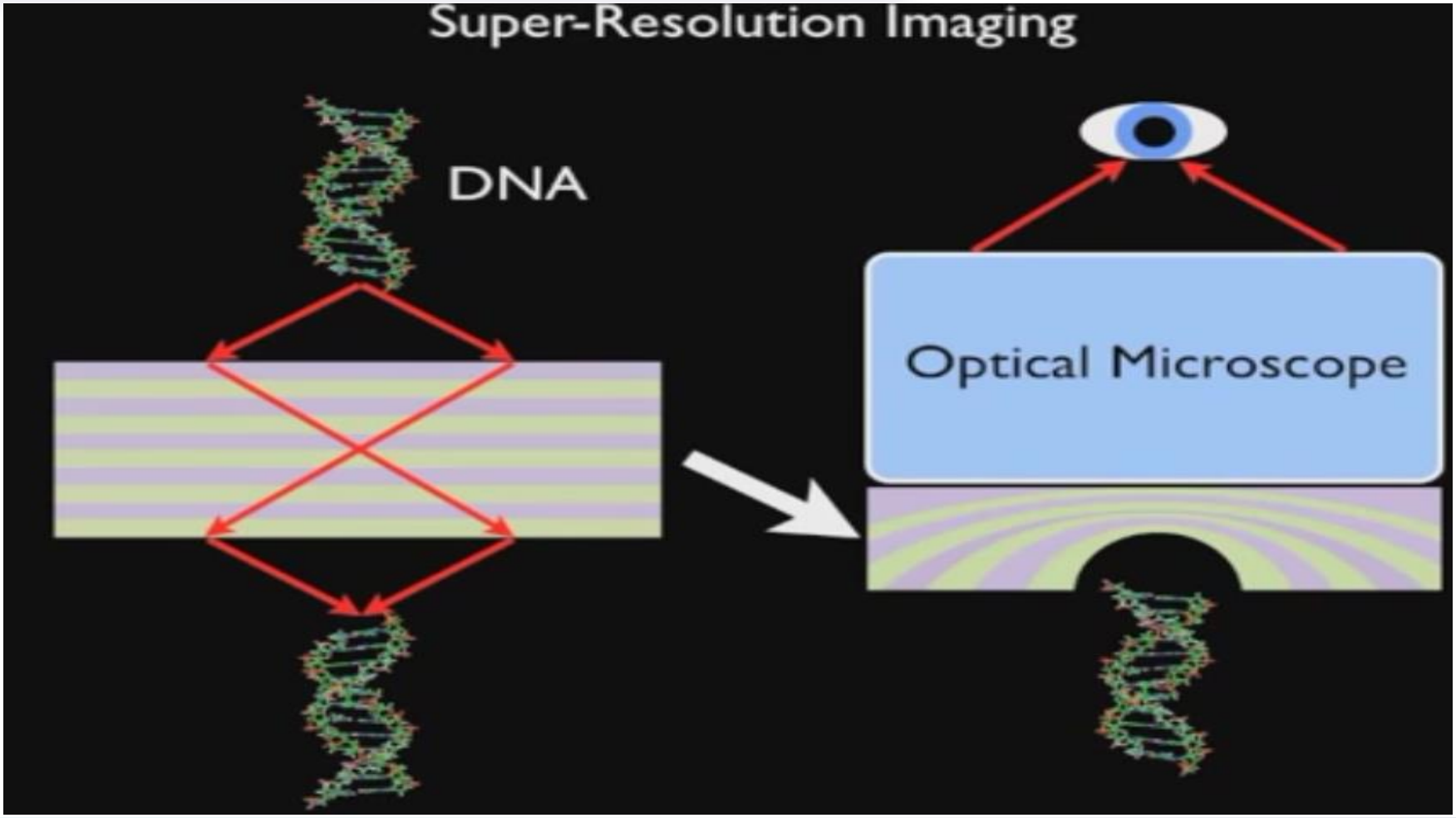




The phenomenon of negative refraction



Perfect imaging **in** Medicine

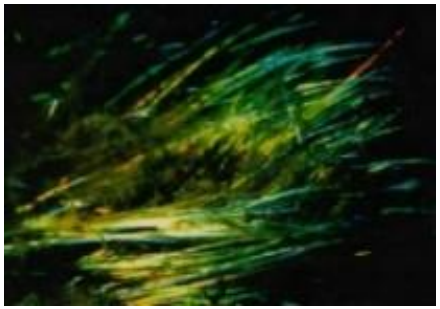


Application of negative refraction

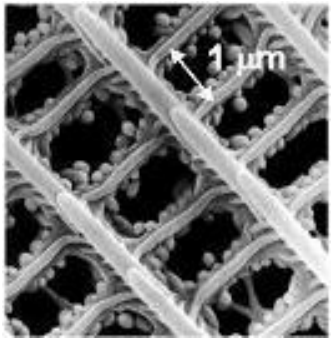
Negative refraction from nature

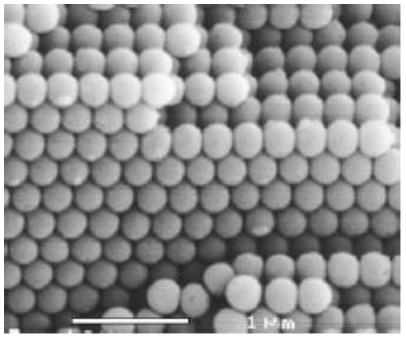
Butterfly

Opal

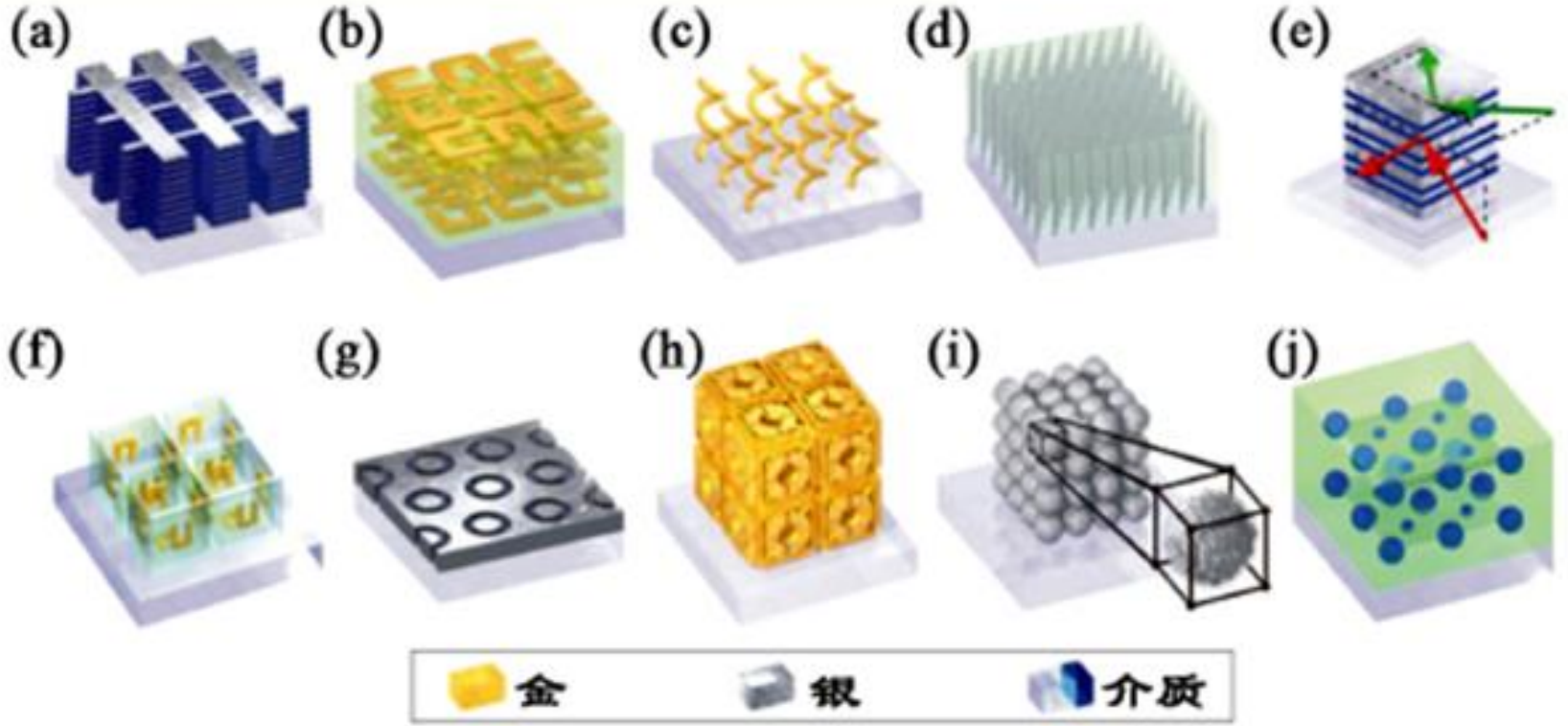


Sea mouse



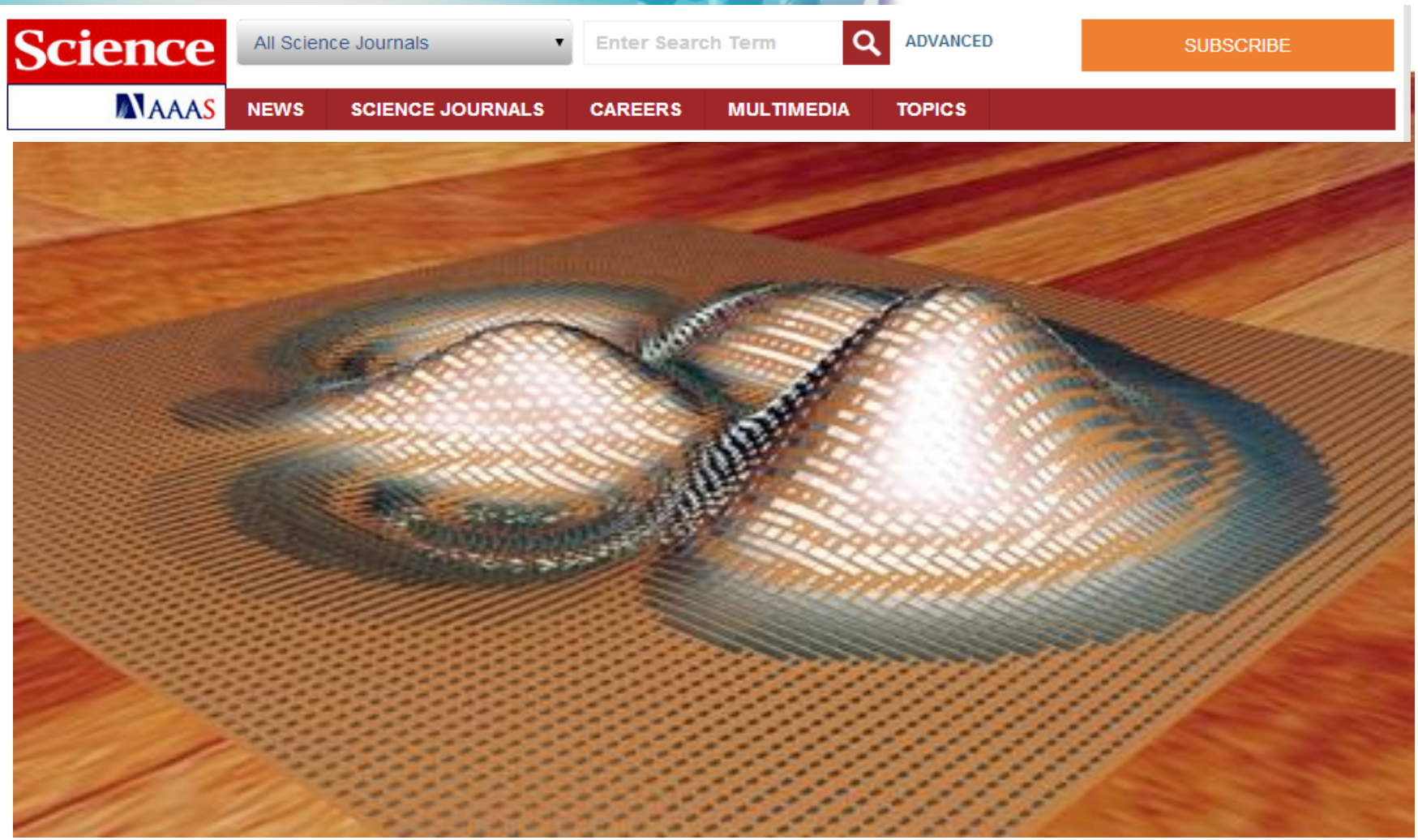


Artificially designed materials



I believe you can make these structures

Latest progress in September 2015



Making 3D Objects Disappear

Xiang Zhang

Faculty Scientist

Chancellor's Professor,
Director, NSF Nano-scale Science and Engineering Center (SINAM)
Department of Mechanical Engineering
University of California, Berkeley

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- A "skin cloak" barely 80 nanometers in thickness
- The first time a 3D object of arbitrary shape has been cloaked from visible light
- Artificial nanostructures engineered with electromagnetic properties not found in nature

Our group 's main research

- The acoustic metamaterial parameters
- Relations parameters and acoustic wave
- Relations parameters and refractive index
- Realization of material parameters

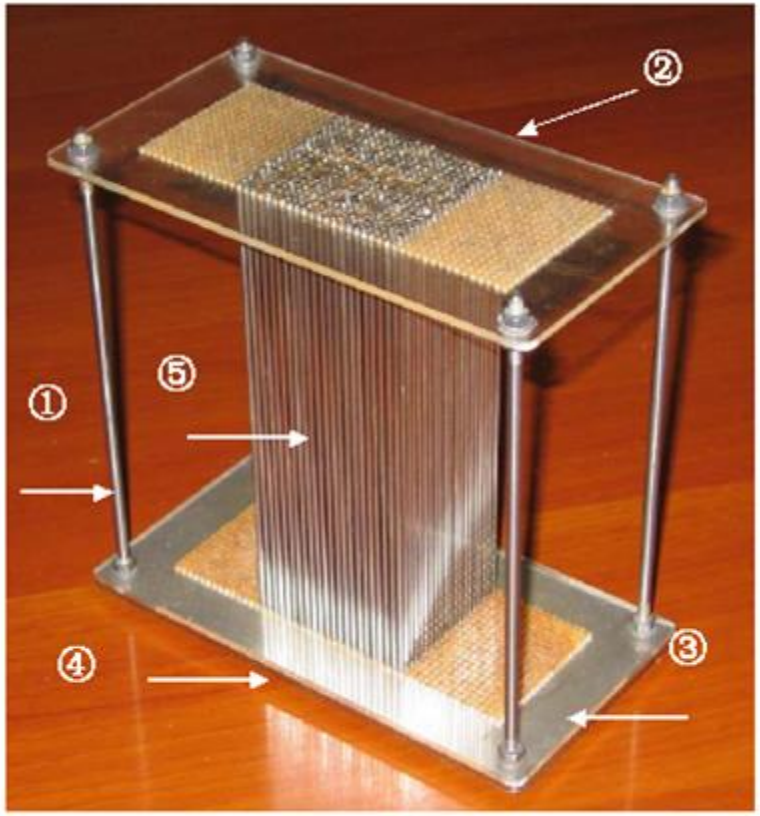
Acoustic metamaterials

Acoustic Wave manipulation

Acoustic metamaterial structure

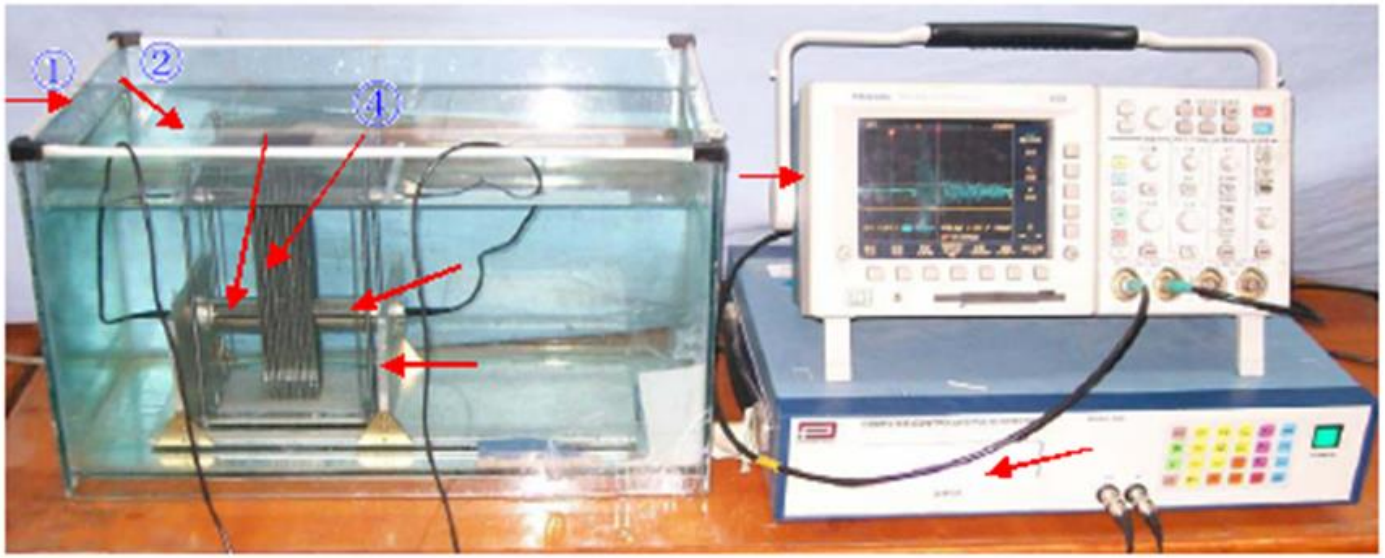
Examples of phononic crystals with periodicities in one, two and three dimensions.**Left**: A one- dimensional phononic crystal consisting of elastic layers made of materials with different mechanical properties. **Center**: A two- dimensional phononic crystal consisting of elastic cylinders in a backround elastic material. **Right**: A three dimensional phononic crystal of spheres in a backround elastic medium.

A simple model of metamaterials



① 双头螺柱、② 上亚克力板、③ 下亚克力板、④ 底板、⑤ 钢柱

Experimental conditions



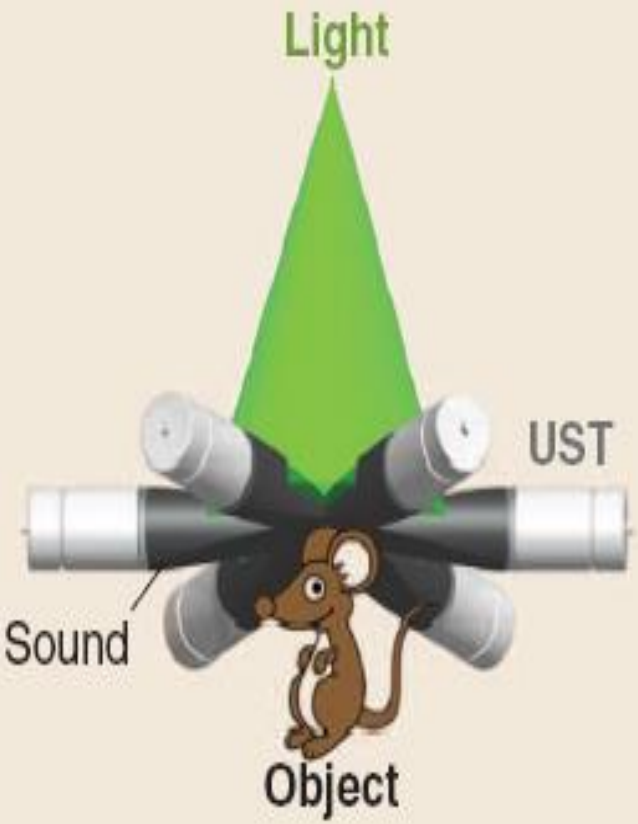
① 水箱、② 水、③ 激励探头、④ 样品、⑤ 接收探头、
⑥ 夹具、⑦ 示波器、⑧ 脉冲发生/接收仪

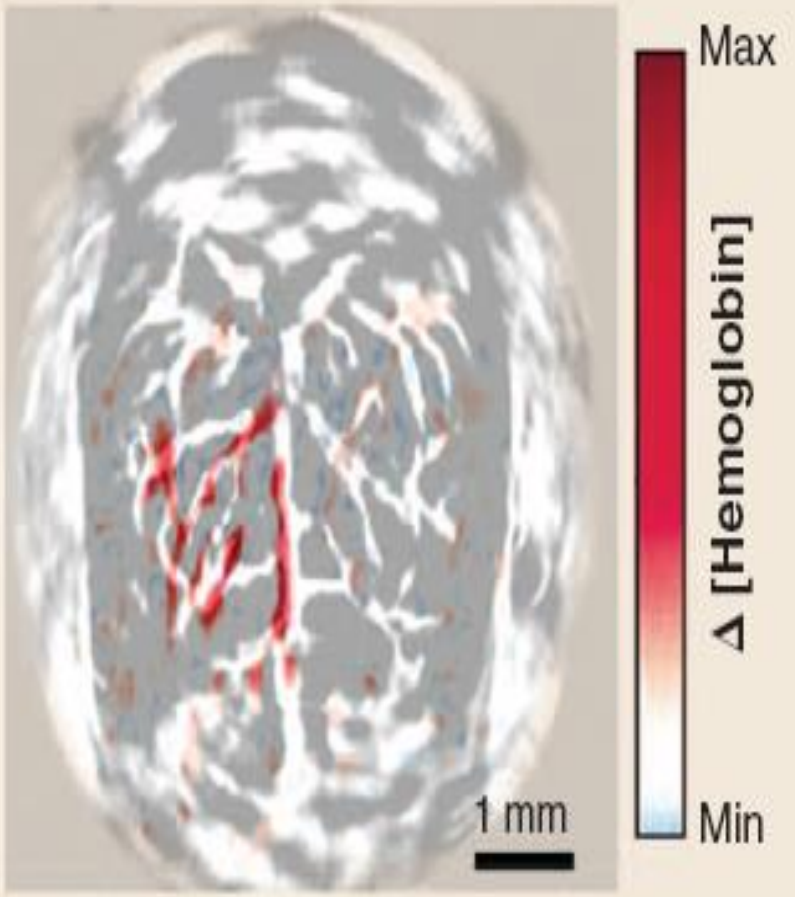
Current Research Details

How to achieve high targets

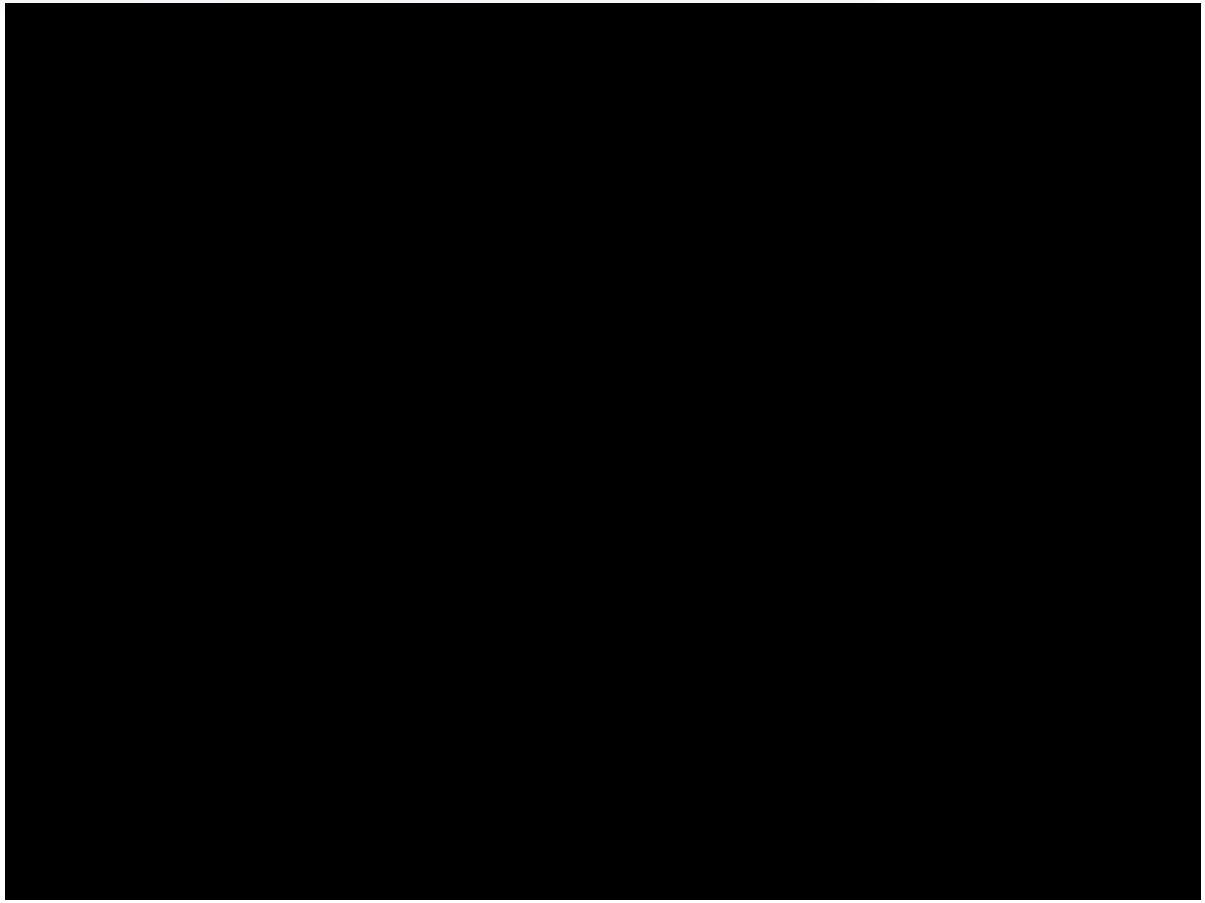
Acoustic metamaterials + Biomedical engineering

Photoacoustic imaging technology

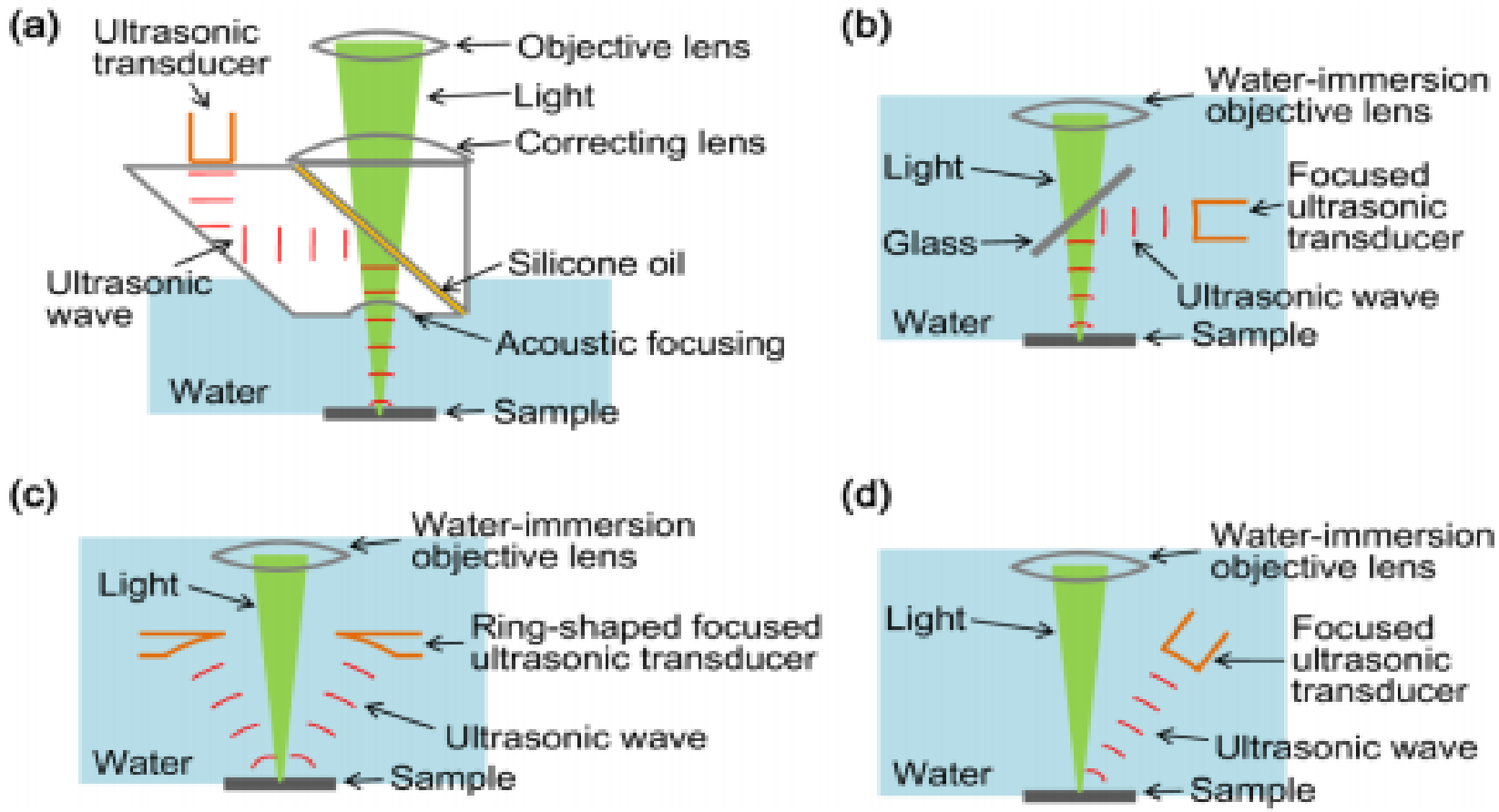




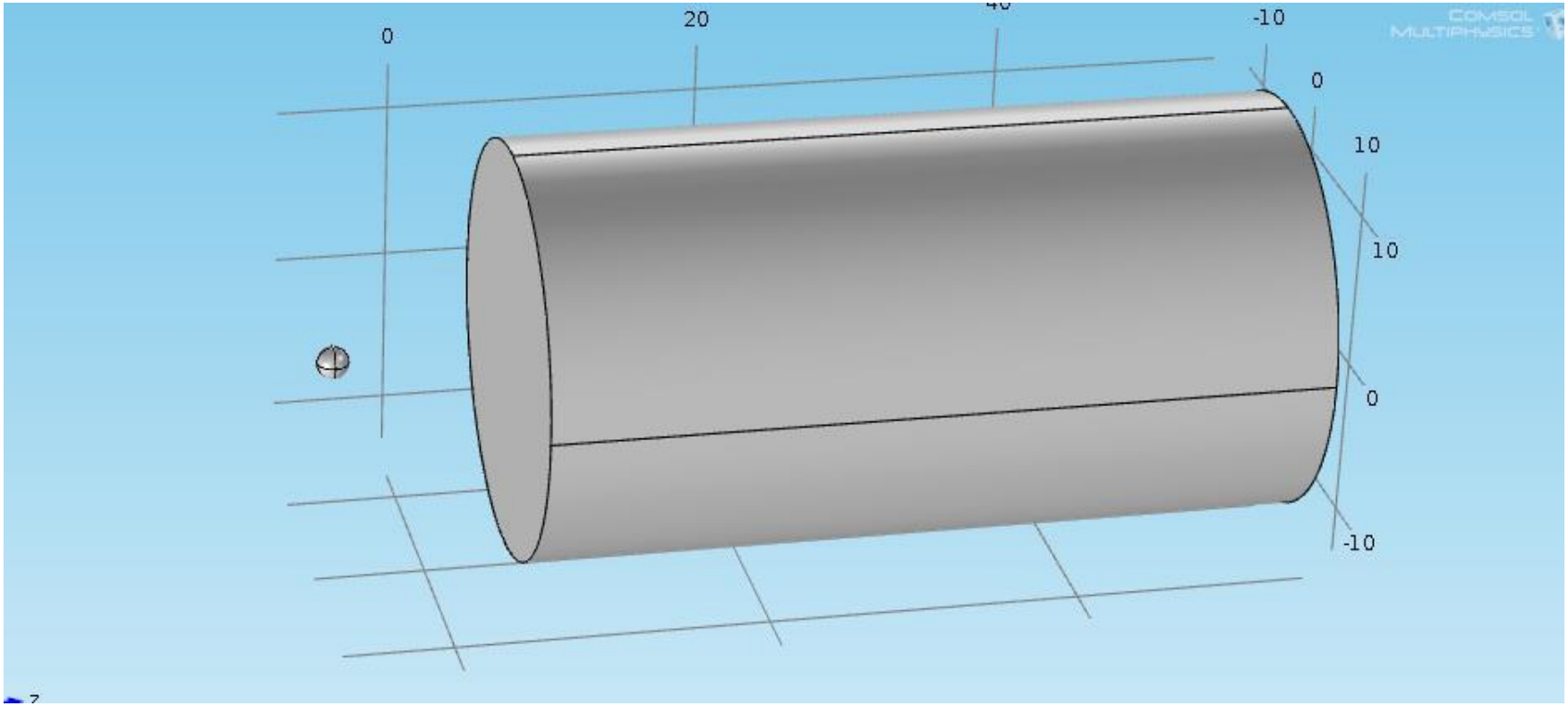
Photoacoustic technology in the future



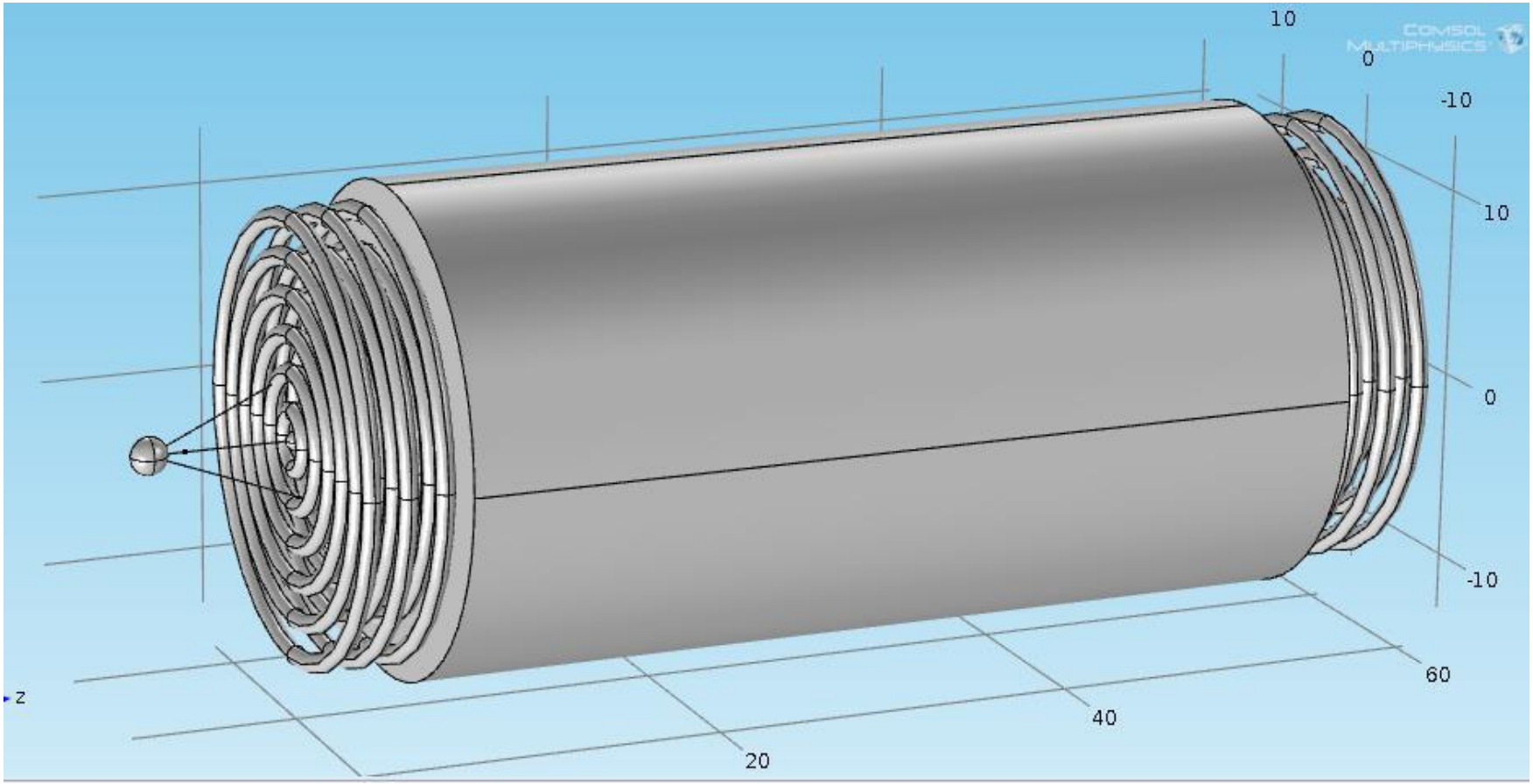
To find Scientific problems



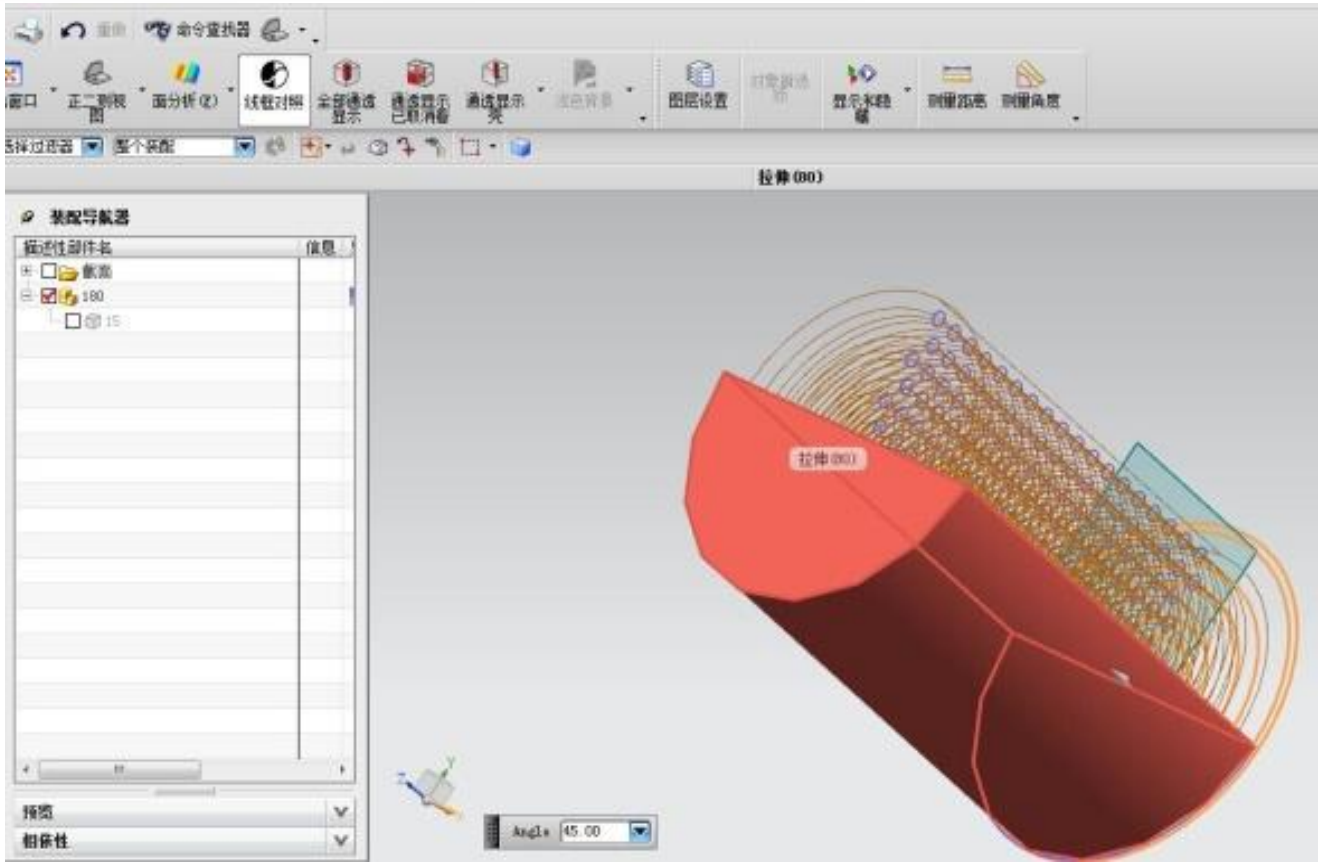
To find a special direction



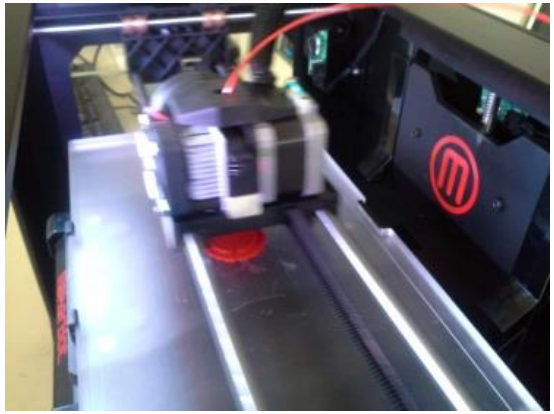
Profile of internal structure

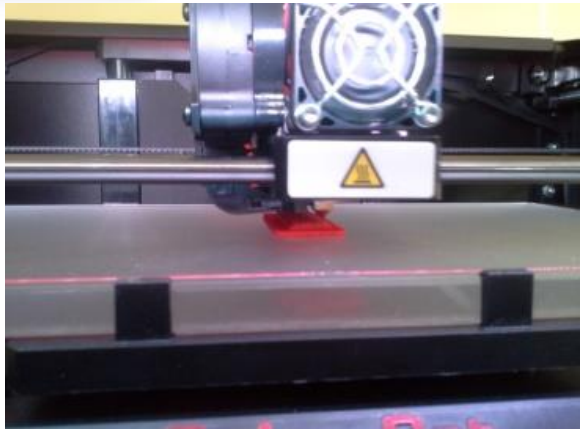


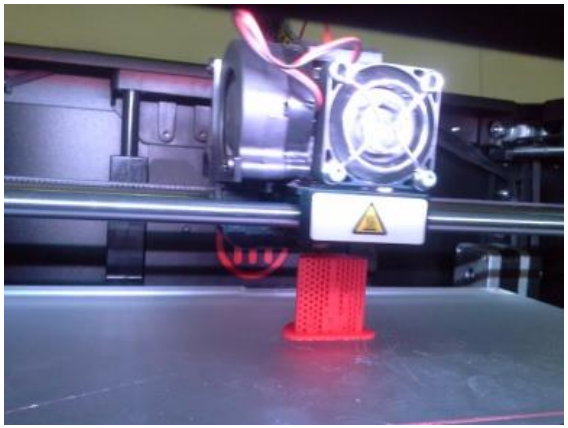
Lens preparation process

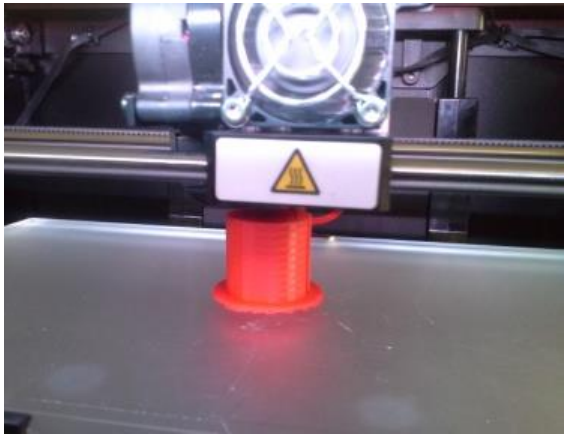


3D printing technology



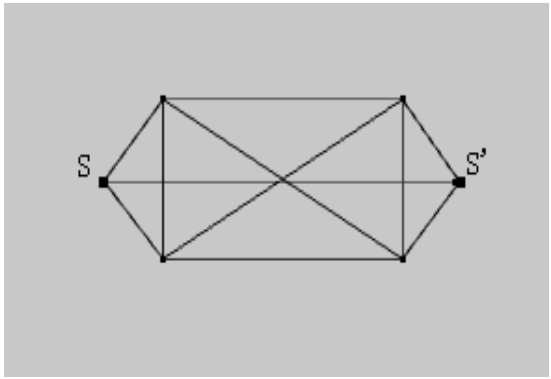


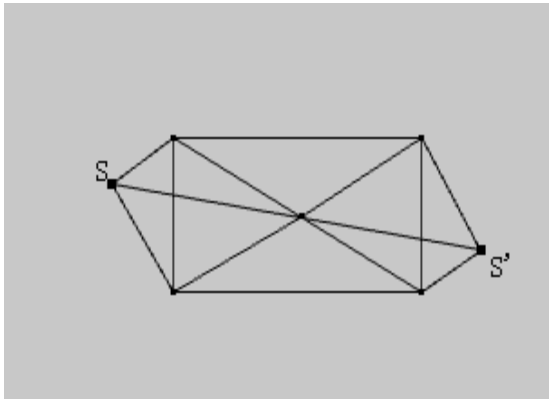


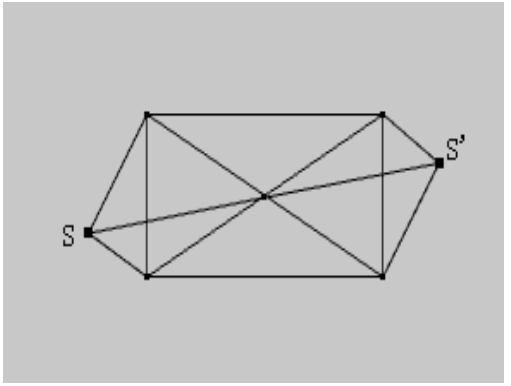


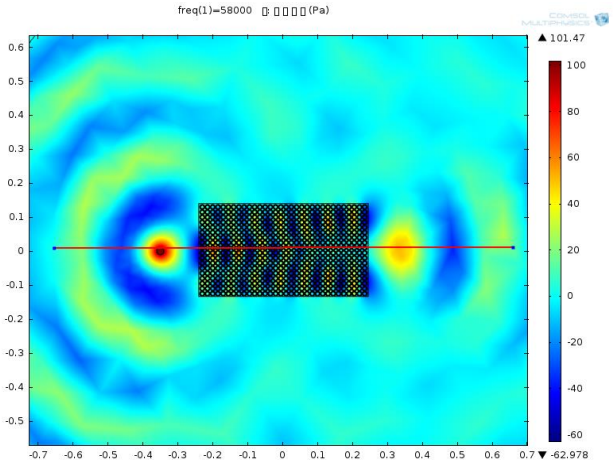
Finished metamaterials lens

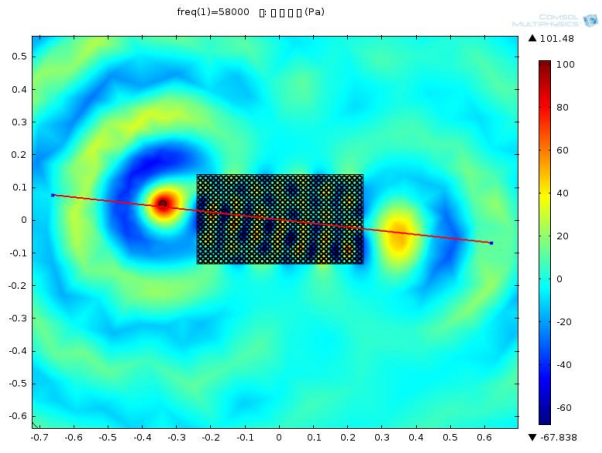
Analysis of negative refractive

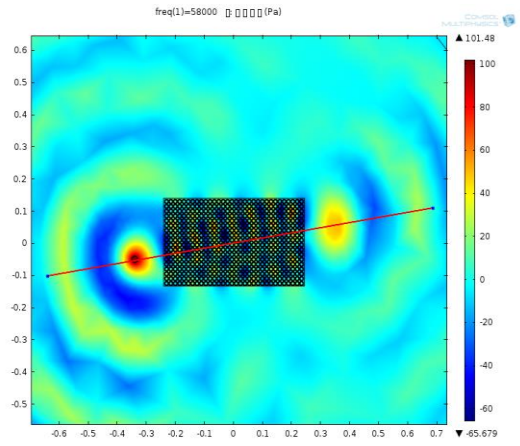




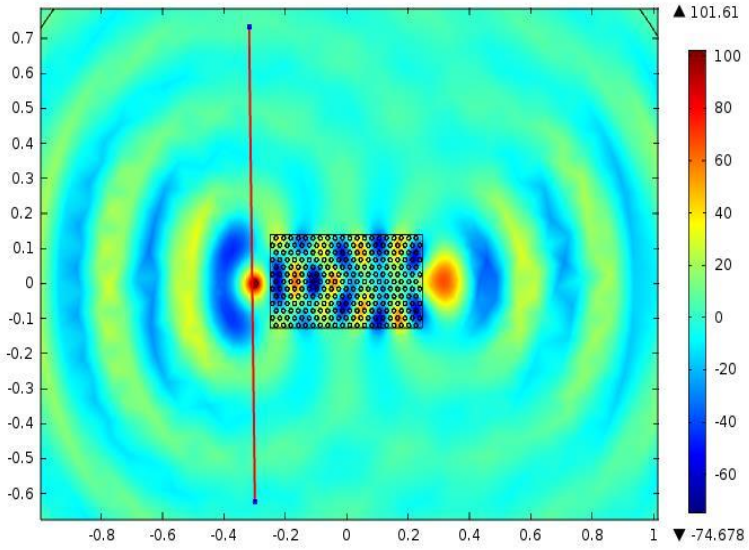


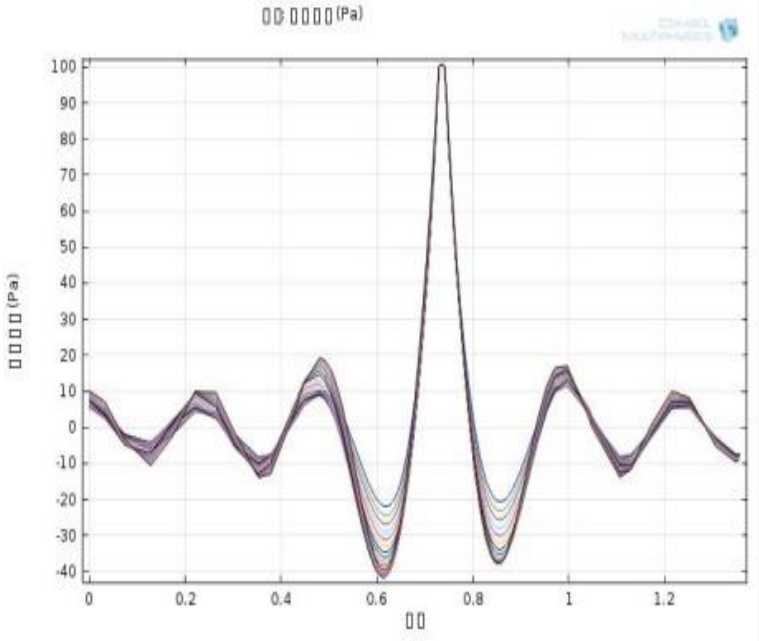




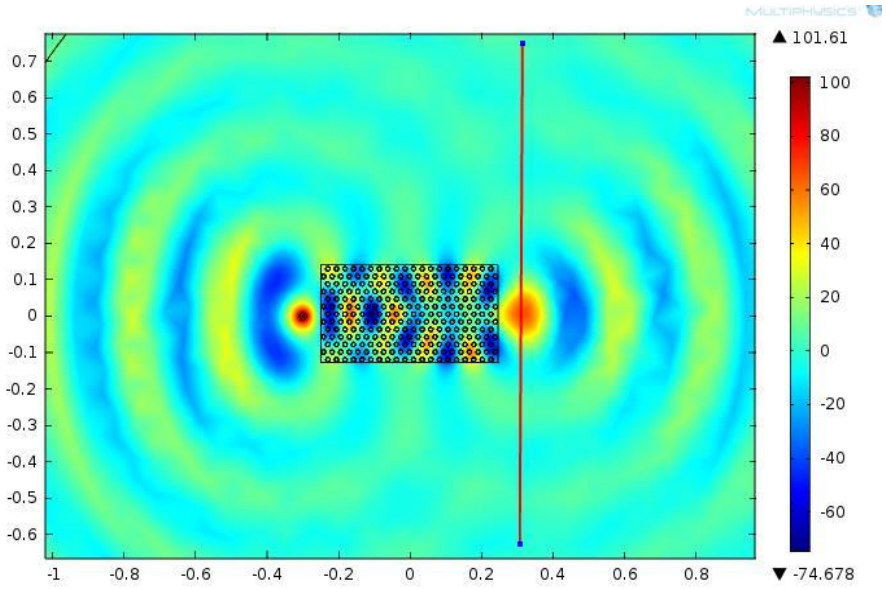


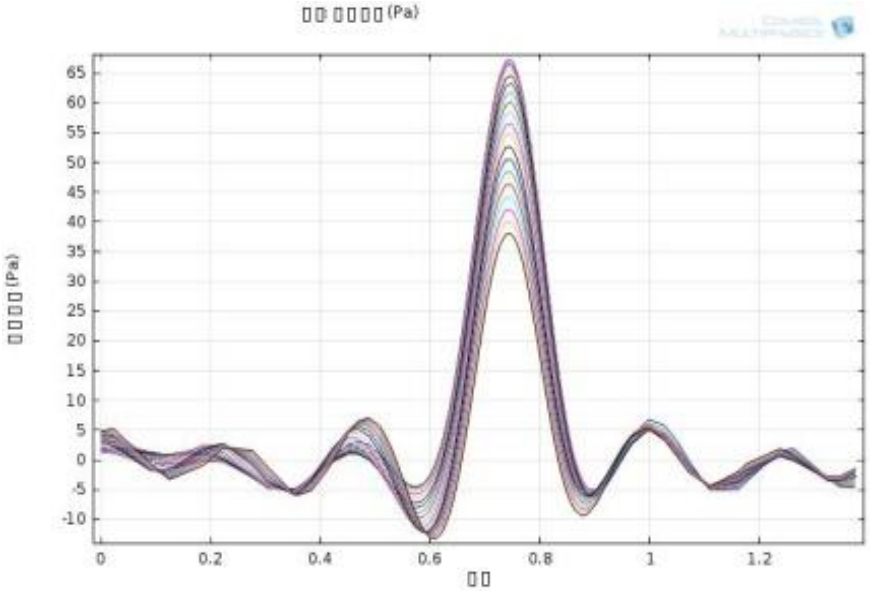
The two-dimensional pressure distribution



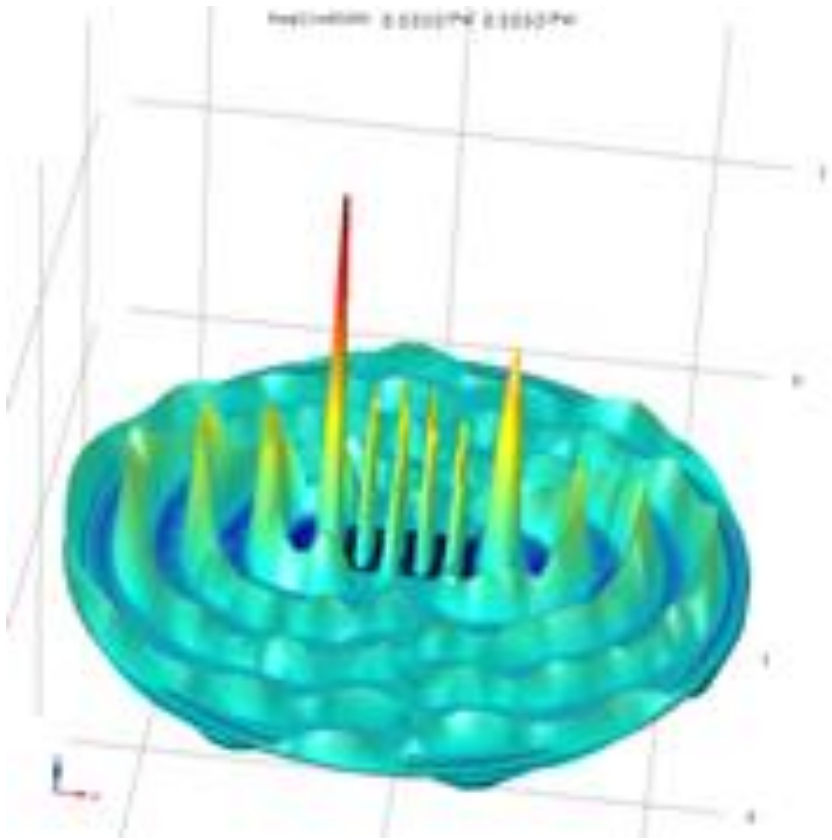


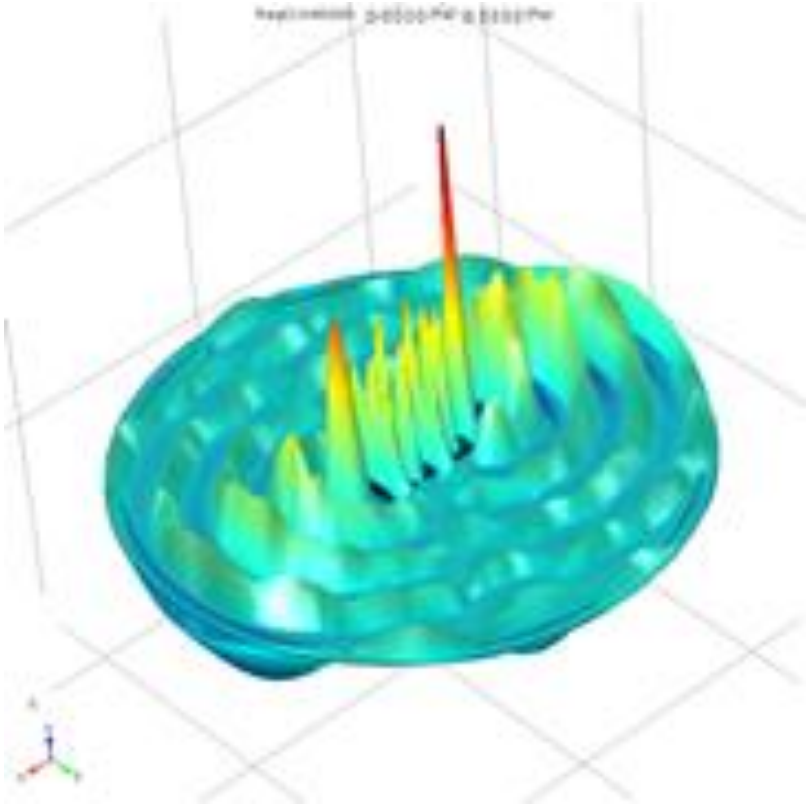
The two-dimensional pressure distribution



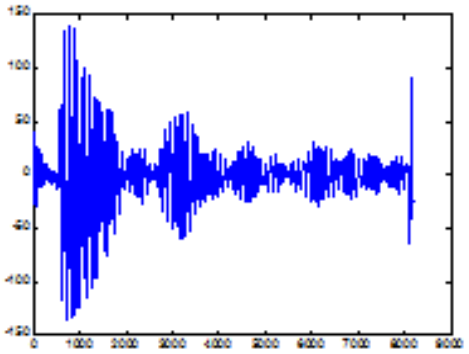


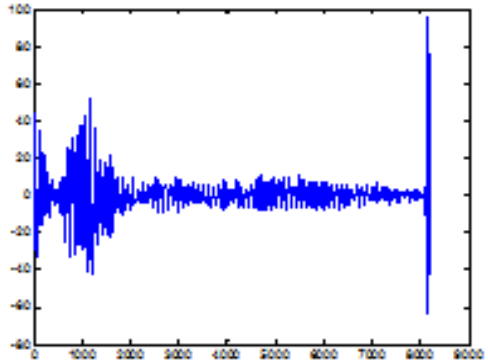
3 dimensional effect

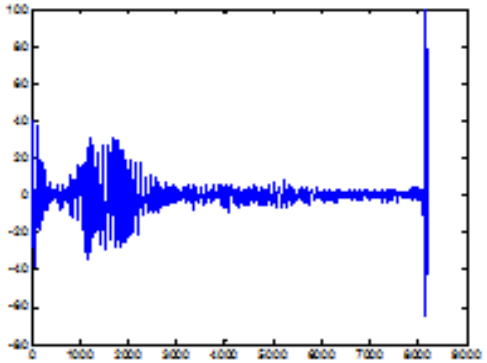


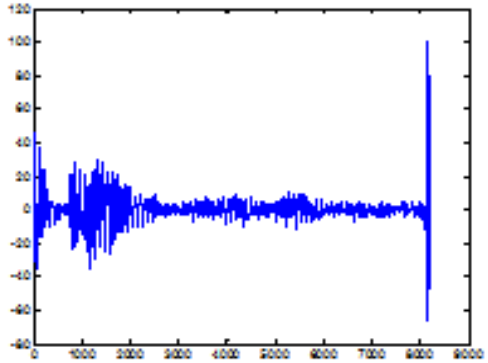


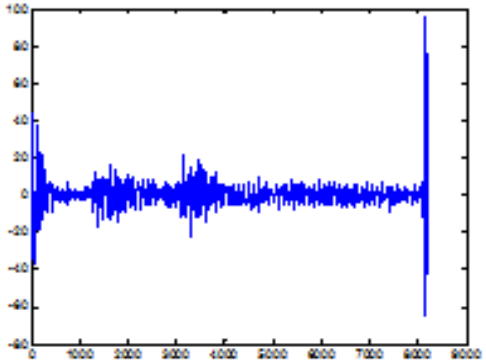
Acoustic wave data in test

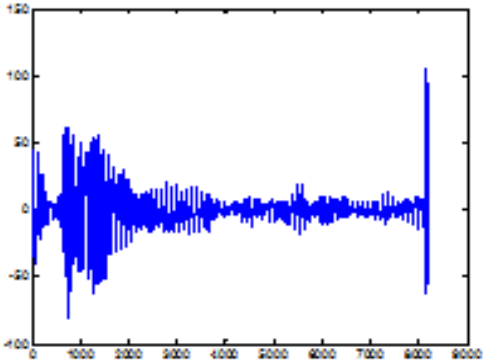












Focused Ultrasound in Brain

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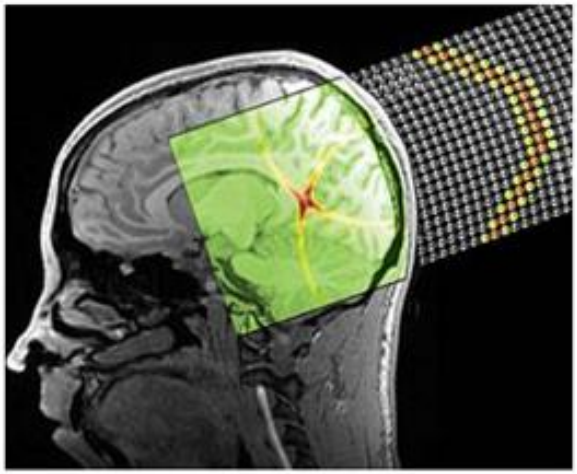
Researchers Create 'Sound Bullets': Highly Focused Acoustic Pulses Could Be Used as Sonic Scalpels and More

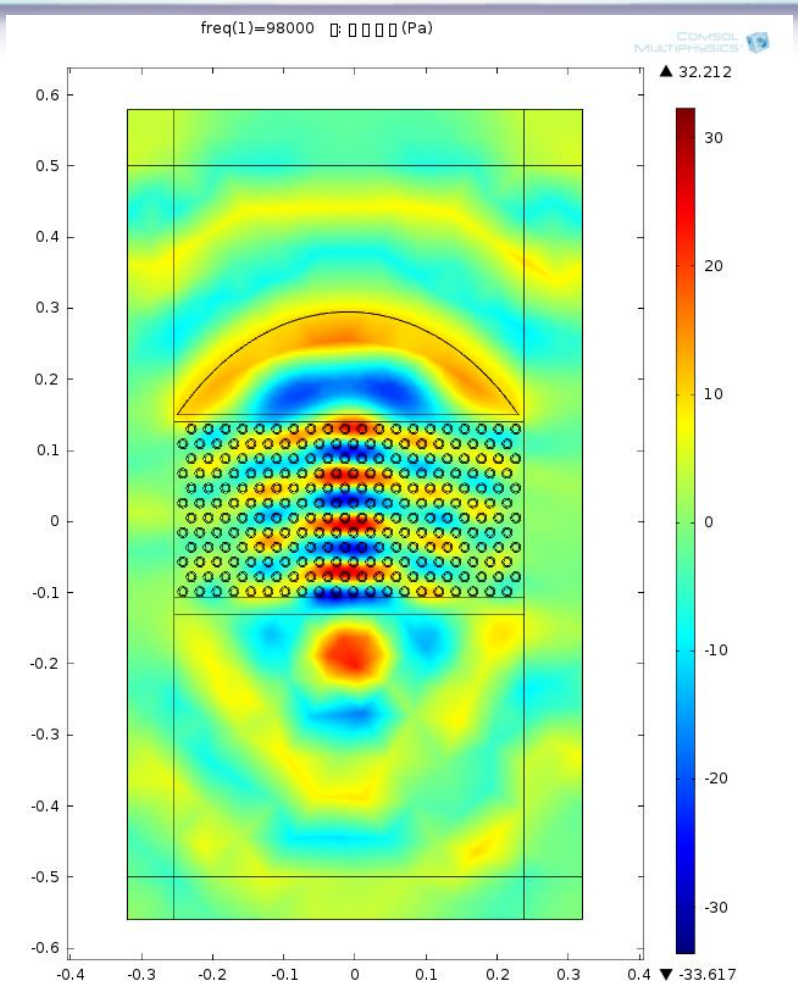
Apr. 22, 2010 — Taking inspiration from a popular executive toy ("Newton's cradle"), researchers at the California Institute of Technology (Caltech) have built a device -- called a nonlinear acoustic lens -- that produces highly focused, high-amplitude acoustic signals dubbed "sound bullets."

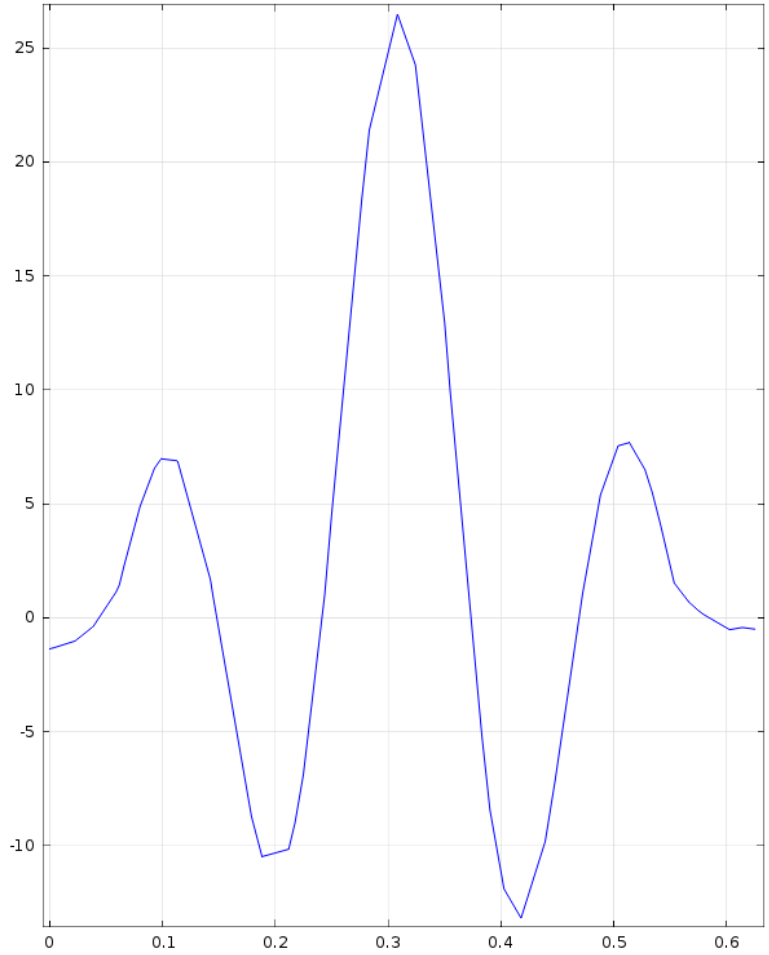
The acoustic lens and its sound bullets (which can exist in fluids -- like air and water -- as well as in solids) have "the potential to revolutionize applications from medical imaging and therapy to the nondestructive evaluation of materials and engineering systems," says Chiara Daraio, assistant professor of aeronautics and applied physics at Caltech and corresponding author of a recent paper in the *Proceedings of the*



Potential employment of a nonlinear acoustic lens to generate a sound bullet for hyperthermia

Design results achieved





End of speech

THANK YOU

Look forward to in-depth exchanges and cooperation